LVIII. Observations on the construction of voltaic batteries; with a description of a battery exhibited at the Royal Institution of Great Britain, June 3, 1836 in which an uniform and powerful current is sustained for any period required

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valleys which stretch between the Kyárda-dún and the valley of Pinjór, in the Sivalík or sub-Himálayan belt of hills, associated with bones of the fossil Elephant, Mastodon, Rhinoceros, Hippopotamus, &c. So far as our researches yet go, the *Sivatherium* was not numerous. Compared with the Mastodon and Hippopotamus (*H. Sivalensis*, Nobis, a new species characterized by having six incisors in either jaw,) it was very rare.

Northern Doób, Sept. 15, 1835.

LVIII. *Observations on the Construction of Voltaic Batteries; with a Description of a Battery exhibited at the Royal Institution of Great Britain, June 3, 1836, in which an uniform and powerful current is sustained for any period required.*
By FRED. WM. MULLINS, Esq., M.P., F.S.S., &c.*

HAVING for some years devoted all the time I could spare from other avocations to researches in voltaism and electro-magnetism, I frequently experienced considerable inconvenience from the impossibility of keeping up an equally powerful current of electricity for a period sufficiently long to answer my purposes; and in one particular instance, which I shall more especially refer to in a future paper, as connected with a very important discovery, the obstruction to the inquiries I was then making was so great, that I resolved, if possible, to conquer the difficulty, and conceived that notwithstanding the disappointments that had previously attended similar attempts, some means might still be discovered by which those consequences of chemical action on the metals employed in the galvanic circuit, and which Sir Humphry Davy and other distinguished philosophers had decided to be the chief cause of the decline of electric power, might be prevented, or, at all events, considerably diminished. I therefore commenced a series of experiments on this subject, in the course of which it struck me that a conducting substance interposed between the two metals would effectually protect *both* metals from the injurious effect of the gases and oxides formed while the battery was in action, while the electric current would find a free passage, and a surface of copper, or whatever other metal performed *its* functions, in the fittest state to receive it from the electrolyte. I had been previously in the habit of using membranous substances as conductors of voltaic electricity, in a course of experiments in which I had been engaged with the view of obtaining a new mode of developing voltaic power; and having found that thin membranes, when moistened in alkaline or acid solutions, af-

* Communicated by the Author. An abstract of Professor Daniell's paper on the Constant Voltaic Battery, recently constructed by him, will be found in our last volume, p. 421.

forded a free passage to the electric fluid, I concluded that my object would be fully attained by their employment in the voltaic circuit. I accordingly prepared a very thin calf's bladder, and having placed in it a coil of thin sheet copper, with a small quantity of solution of sulphate of copper, I immersed both in an earthenware pot containing a cylinder of zinc fitting close to its inner surface, and distant from the surface of the copper an inch and a quarter, and a sufficient quantity of diluted sulphuric acid, in the proportion of 5 of the acid to 100 of water; and on testing the power of this battery with the voltmeter, I found that the first deflection suffered very little diminution for several hours, though I had made no alterations in the fluids used, nor in any way disturbed the arrangement (in this experiment the pot used was only two and a half inches in diameter and three deep). In a second experiment, made with the same battery and with the same solutions, having connected it with an electro-magnet of the horse-shoe form, four inches in length and five eighths in diameter, the magnet sustained 50 lbs. attached to the keeper for three hours. Having thus proved the possibility of obtaining a continuous and equally powerful current for a long period, it next became a question whether the power could not be still further increased and prolonged by the use of other conducting liquids in contact with the same quantity of metallic surface; and after a long course of experiments upon the nature of chemical action on metals in voltaic connexion, and the comparative effects of different electrolytes of different degrees of strength,—the results of which I consider sufficiently important to form the subject of another paper,—I found that of the various acid, alkaline, and saline solutions tested, muriate of ammonia in the proportion of 5 parts of the saturated solution to 100 of water, gave me the best conducting fluid, combined with the least injurious action on the zinc surface; in fact, so slight that, after several days of constant action, the zinc plate, which was amalgamated, was scarcely corroded or reduced in thickness.

It next became important to examine what connexion existed between the power produced and the distance between the zinc and copper; and it appeared natural to conclude that the more remote the surface of the copper from that of the zinc, the less would be the effect produced on completing the circuit; but, as I was aware that great diversity of opinion existed upon this subject, with the view of fully satisfying myself with respect to the best mode of construction of voltaic batteries, I prepared an apparatus by means of which I was enabled most accurately to measure the increase or diminution

of power according to the relative distances of the two metals. It consisted of a cylindrical earthenware vessel, four inches in diameter, in which was placed a cylinder of zinc, as close to the inner surface as possible: the centre contained a copper coil, of one inch diameter, inclosed in a membranous bag, and there were four other copper coils, of greater and different diameters, so constructed, however, that the largest did not contain a greater surface of copper than the smallest. When the coil of least diameter was used, the deflection of the voltmeter only reached 60° ; on introducing the next in size and removing the first, the deflection increased to 65° ; the third brought the needle to 71° ; the fourth to 74° ; and the fifth, which was distant only a quarter of an inch from the zinc, to 87° . I repeated the experiment in an oblong trough, with square plates of zinc and copper, gradually advancing the zinc to the copper, and with the same results; thus demonstrating, that in the construction of voltaic batteries, whether square or cylindrical, the nearer the surfaces of the metal are brought, the greater will be the power developed.

It may be well here to state that in the course of these experiments I found that, in each pair of plates, an increase of zinc surface beyond a certain limit will not give an increase of power, and consequently I am of opinion that a larger quantity of zinc than is requisite is employed in all the batteries in general use.

Having thus experimentally ascertained the proper distances of the metals, as well as the best conducting fluids, I constructed a single voltaic battery, in which I brought the principles already stated to bear, as much as the interposed membrane and other circumstances would permit, and of which I will now give a brief description: in an earthenware pot, six inches deep and four wide, I place a cylinder of amalgamated zinc, standing on three legs, half an inch long, cut out of the cylinder, the depth of which, including the legs, is only two inches; within this cylinder, and at three eighths of an inch distant, stands a copper vessel, having a rim a quarter of an inch wide surrounding its outer edge, round which the bladder is tied; the bottom of the vessel rests on a circular piece of baked box wood, which projects one fourth of an inch beyond the cylinder; a thin oblong bladder, well cleaned and moistened, is drawn over all and fastened round the upper rim by a string, the wood at bottom preserving it from contact with the copper, which would otherwise injure the membrane. This cylinder, which is the depth of the pot, is pierced with six holes equidistant from the top and bottom, which communicate with an *inner* cylinder, separated from the outside one

by a space of three fourths of an inch, the bottom being on a level with the lower edge of the holes and soldered to the larger cylinder; this chamber is intended to hold crystals of sulphate of copper when required, and to receive the solution, which should not rise higher than the *upper* edges of the holes. A small quantity of the ammoniacal solution is to be poured *outside* the membrane until it rises to the upper edge of the zinc; the latter solution does not require renewal; the former will require the addition of a few crystals of the sulphate every four hours. An electro-magnet of the horse-shoe form, the limbs of which were five inches long and one inch in diameter, having four coils of thin wire, each coil containing thirty feet, when connected with a battery of the dimensions given, sustained for several hours a weight of 112 lbs.; but this is not a safe test, for I have always observed that electro-magnets to which weights have been for some time attached, lose their temporary power to a certain extent, and acquire a slight permanent power. This arises, I apprehend, from the straining of the soft iron and the consequent unevenness of the poles, as well as from a certain change in the contiguity and internal arrangement of its particles, and presents, in my opinion, an insurmountable obstacle to the useful application of electro-magnetic power in the way alluded to by Mr. M'Gauley at the late meeting of the British Association.

Upon the same principle, conjoined with another which in a future paper I shall more particularly advert to, I have constructed a somewhat different form of battery for intensity effects; it consists of a number of zinc and copper cylinders, of the same proportions as those before described, placed in a pot of the same size as that already mentioned, one within the other, the copper cylinders being lined with *caoutchouc* for insulation. In this battery the power is immense in proportion to the quantity of the metals used, and arises, I conceive, from the application of a principle which I believe is quite novel in the construction of voltaic batteries, namely, that of *diminishing* the metallic surfaces as the fluid in its onward passage *accumulates*, thus acquiring *increased* force in proportion to the smallness of the substance to which it is restricted. By merely altering the connexions of the plates, which by the mode I have adopted can be done with the utmost facility, this battery can be turned into a powerful quantity one, and for *both*, a wine-glass full of the solutions is amply sufficient.

In a future paper I hope to be able to enter at greater length into these and other results of the investigations in which I have been for some time engaged.

Beaufort House, Killarney,
Sept. 1, 1836.

FRED. WM. MULLINS.